AL.2.1986-732

Long Range Plan

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Alberta
RESEARCH COUNCIL
December, 1979

DDN 3452962

Long Range Plan

ALBERTA RESEARCH COUNCIL
December, 1979

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Long Range Plan: Highlights

HIGHLIGHTS

This is the Alberta Research Council's Long Range Plan, being the result of consultations with representatives of government, industry and universities, and extensive participation by Research Council staff.

The Long Range Plan has four main thrusts, which are:

- Expansion of research on oil sands and heavy oils
- Major expansion of research on coal
- Further development of services to industry and the seeking of new ways to work with industry and Alberta Economic Development
- Focusing a substantial effort in frontiers of science likely to be of long-term economic benefit.

Other elements of the Long Range Plan include:

- Looking for opportunities in areas where there is significant Canadian technological strength
- Reducing the effort in mature technologies and reorienting that work towards new fields
- Encouraging closer cooperation with the universities
- Endeavoring to become better known in Alberta
- Striving for a higher profile on the national and international scene.

The Long Range Plan is divided into two parts. The first part explains the long range strategy of the Alberta Research Council. Part two provides in more detail strategies and programs for each proposed major area of activity.

Long Range Plan: Introduction

INTRODUCTION

This is the Alberta Research Council's Long Range Plan. A Crown Corporation founded in 1921, the Research Council operates under the Research Council Act, which gives it a mandate to advise the government on scientific matters and to promote responsible economic development through the use of science and technology.

During the last several months, eighteen Research Council task forces talked to representatives of the private sector, government and the universities. Their work led to a discussion draft which was reviewed by people in those three sectors and whose comments were incorporated into this Plan. The Research Council was gratified by the courtesy extended to it during this work and wishes to thank all those people who took so much of their valuable time to help.

This Plan is believed to be the first for the Research Council and it is proposed to review and update it annually. For the time being, however, it will serve as a firm base for the future development of the Research Council. The first part of this document contains the proposed long range strategy of the Alberta Research Council. It starts by reviewing provincial objectives, particularly as established by the Government of Alberta. It then takes stock of the present situation — the natural, human and economic resources of the province and the capabilities of the Alberta Research Council. This review reveals opportunities, from which are derived some objectives for the Research Council. A strategy is proposed to achieve these objectives and, finally, an outline of a plan to follow that strategy is suggested.

The second part outlines for each of the major areas of activity the proposed research strategy. The table presented at the end of this document indicates, in terms of man-years of research staff, the present (1979) and the five-year effort (1984), as well as the long range technological outlook (up to twenty-five years).

Following approval of this research plan, steps will be taken to implement it, giving due consideration to the financing and organization of the work.

Part I:
Long Range Strategy

PART I. LONG RANGE STRATEGY

PROVINCIAL OBJECTIVES

One of the principal objectives of the Alberta Government is to foster economic development, with a view to reducing the province's dependence on the export of unprocessed resources, and to promoting balanced growth across the province.

As stated by the government on several occasions, the thrust of the province's economic strategy is to build on Alberta's strengths — its basic renewable and non-renewable resources and the talent of its people. This strategy has two elements: to maintain, strengthen and improve the base industries of agriculture and energy; and to capitalize upon opportunities leading to the diversification of the province's economic base. For example, opportunities for increased agricultural production and food processing can be exploited; the skills of Albertans in science, technology, engineering and project management can contribute to making the province a leading research and development centre; the recreational potential of many parts of the province can be developed further; the province's geographic location and developed infrastructure can lead to the further development of the North.

There are many activities that will contribute to this strategy. One activity is the performance of research and development to give competitive advantage to local groups and to develop specialized industry in Alberta. It is this activity which is of greatest concern to the Alberta Research Council.

THE PRESENT SITUATION

THE PROVINCE

Natural resources.

The most evident feature in the province's present situation is its large natural energy resource. Rising prices are spurring new finds of conventional oil and natural gas, but supplies of these commodities are gradually dwindling. The enormous reserves of bitumen in the oil sands, roughly equivalent in extent to the oil resources of the Middle East, have recently become economic. The extraction of this resource is difficult, however, and it is vital to learn how to improve the recovery. Coal is a major resource, exported for metallurgical production and used for electric power production in the province. Potentially it could be used to produce liquid fuel, the premium fuel form. Although this is not yet economic, it is probable that it will become so in the next twenty-five years. Renewable forms of energy such as solar, wind, biomass and geothermal are not economic now and not likely to play a major role in the province. In special situations they may be practical for small scale and local use. There is a limited potential for hydro-electric power development.

There are adequate supplies of minerals such as sand, gravel and limestone, but there are no significant deposits of metallic minerals except for a large iron deposit in the Peace River District which has long defied commercial extraction. Some uranium has been found in the northeast and active exploration is continuing there.

Despite the spectacular growth of the energy industry in recent years, agriculture is still one of the largest employers in the province and it remains the basic foundation of the economy. About 40 percent of Alberta's total land area is utilized for agricultural production and 60 percent is under forest cover. Increased agricultural production will probably come about through improved management of presently cultivated land, although some increase can be expected from the settlement of new land. Climate may be a constraint to large-scale development of new land in the northern and western portions of the province where the length of the frost-free period is limiting to crop production. In the southern portion of the province, the length of frost-free period is not as serious a constraint to agriculture but the relatively low rainfall may be limiting in some years. To some degree this problem can be overcome with expansion in the irrigated acreage.

Although the supply of surface water, mainly in the north, is adequate for town development, a great deal of it will be required for large energy projects. The groundwater supply is about one tenth that of the surface water, is saline to varying extents, and is distributed thinly over the province. In the south, water is not plentiful — a situation which hampers agriculture and human settlement. Water resources might in the long term be a limiting factor to the development of the province and must therefore be used with care.

The production and processing of food is one of the province's most important economic activities and will remain so for a very long time. The processing of locally grown agricultural crops is somewhat limited and increasing attention should be given to the agricultural processing industry.

Fibre from Alberta's extensively used softwood forests is an important economic product. The production of sawtimber and pulp from softwoods is a mature industry. The hardwood, constituting about one-quarter of the total Canadian supply, is largely unused.

Economic resources.

The major industries of the province are petroleum- and agriculture-based, serving North American and some offshore markets. An expanding diversified secondary industry serves the provincial market in the main, with growing success in some specialized products in export areas. The local market is small — about two million people — while others are distant. There are reasonably assured markets for the province's major products — food and energy.

An important feature of Alberta's economy is the availability of funds for investment for the long-term benefit of the province.

Human resources.

Alberta's two million people, many of whom have been trained and educated in the province's full range of high quality secondary, postsecondary and postgraduate educational facilities, are a basic resource. In these people there is invested a great deal of skill and know-how which is already being used to develop the provincial and national economies. As the demand for energy grows, however, and the province increases its extraction, production, and upgrading of energy resources, there will be a demand for very many more trained people to develop and run the new technology. Diversification of the province's economy will require other trained people. If these human resources do not continue to develop here, the necessary know-how will develop and reside elsewhere, which will constitute an unnecessarily missed opportunity.

THE ALBERTA RESEARCH COUNCIL

The Research Council is the oldest provincial research organization in Canada. It has a staff of about four hundred, about one hundred and sixty being scientists and engineers, the remainder being technical and support staff. For many years the Research Council's principal source of finance was by legislative appropriation, but during the last five years it has undertaken increasing contract work. At the present time about half of its $16 million budget comes from contracts, mostly from government departments and agencies, but with an increasingly significant amount coming from industry. Major government clients for which the Research Council performs work include the Alberta Oil Sands Technology and Research Authority, Alberta Energy and Natural Resources, Alberta Environment, Alberta Transportation, Alberta Agriculture, the Alberta Weather Modification Board, the Alberta/Canada Energy Resources Research Fund, and the Farming for the Future program. In addition, there are relationships with the Petroleum Recovery Institute, the Computer Modelling Group, the Coal Mining Research Centre, Alberta Environment Centre (Vegreville), the Agricultural Research Council of Alberta, the Forestry Research Trust, the Alberta Agricultural Research Trust and the Crop Research Program, through representation on their boards. In all these activities the Research Council performs or advises on research; with the exception of a few very small grants it does not fund research.

The Alberta Research Council has the largest oil sands research group in Canada. The current effort on coal research is modest, but, because of long experience in fuel sciences, could be expanded quickly. Staff working on geology, soils and groundwater perform the role of the geological survey of the province. The groundwater group is the largest in Canada. For many years the Alberta Research Council has operated the Alberta portion of the National Research Council's Technical Information Service. Using this as a base, the Alberta Research Council runs the most comprehensive industrial and engineering services of all Canadian provincial research organizations.

There are many strengths at the Alberta Research Council, including chemistry, chemical engineering, microbiology and civil engineering. Many of these groups have national and international reputations, although some are less effective than they could be because of their subcritical size. Except among peer groups, however, the Research Council is not very well known among the population at large, even in Alberta. It tries to strike a balance between its responsibility to take a long-term view and that of working in more immediate fields in order to be aware of current events. At the present time, the Research Council is reasonably equipped, but is housed in ten largely inadequate facilities, essentially all of them in Edmonton.

OPPORTUNITIES FOR ALBERTA

Alberta, with its economic, human and natural resources, has five major opportunities:

- to strengthen its present economic base through further development of its renewable resources;
- to contribute to Canada's objective of self-sufficiency in energy by development of a viable new energy industry of world scale;

- to exploit that experience by developing skills in science, technology, engineering and project management, thereby investing in Canadians the ability to grasp opportunities which will occur elsewhere in the same fields;
- to bring about development responsibly and with respect for the environment;
- to use its wealth to establish a position in more advanced science and technology in order to prepare the ground for a more diversified economic base.

THE ALBERTA RESEARCH COUNCIL'S GOALS

The Research Council's goals are to perform scientific work in support of the economic and social objectives of the province and in pursuit of the opportunities available to Alberta. More specifically they include:

- provision of technical services to public and private sectors;
- development of useful scientific information and technology for both public and private sectors;
- contribution of practical experience and development of manpower to ensure indigenous participation in establishment of new industries in the province;
- encouragement of the transfer of technology, particularly to the private sector, but also to the public sector.

While it does not plan to perform research in the social sciences, the Research Council wishes to be sensitive to the social implications of the work it performs.

STRATEGY FOR THE ALBERTA RESEARCH COUNCIL

Before the Alberta Research Council's strategy is enunciated, it is worth while briefly discussing some of the ideas and problems behind the strategy.

The first decision to make is whether the Research Council should be passive, in the sense of providing advice and low levels of service to the government and private sectors or whether it should be active in taking leadership of substantial projects, promoting new concepts, and playing a more visible role in trying to encourage and support economic development. Of these two, the active role is likely to be more controversial and involve more risk, but to be more productive. The Research Council believes that it can best fulfil its mission with the second choice and therefore chooses that in preference to the passive role.

To be effective a strategy must achieve a comparative advantage. Insofar as economic or industrial strategy is concerned, it must also be realized that science and technology form only one part; finance, production, marketing and other functions are also important. A successful strategy depends on selectivity, putting resources into areas where there is strength in the market or where there is a reasonable chance of developing strength. In the industrial world this will usually necessitate work in new fields, avoiding those which are mature and have established positions. An exception to this rule is that defence of one's own current, even if mature, business is essential if it is regarded as important and long lasting. There is no sense in committing resources to areas in which most of the benefits will accrue elsewhere. These fundamental points are crucial in development of the Research Council's strategy because they cause two dilemmas. One is that selectivity appears to conflict with the Research Council's public responsibility to be able to provide a broad range of expertise. The other is that the Research Council does not itself have associated manufacturing and marketing capabilities, such as are attached to corporate research departments. The importance of establishing effective communications with suitable commercial capabilities becomes apparent when it is realized that success in many new technologies depends on domination of world markets with proprietary technology.

Bearing in mind these factors and others raised in the prior discussion, the following strategy is proposed to allow the Alberta Research Council to provide a reasonable level of broad service at the same time as it attempts to build a comparative advantage in selected areas of science and technology:

- place major emphasis on energy resources — major emphasis on oil sands research now, with increasing research on coal technology;
- increase assistance to small, medium and large companies by seeking new and flexible working relationships;
- establish enlarged exploratory effort in frontier sciences to provide a foundation for future economic development;
- provide scientific and technical service and advice to government departments and agencies;
- look for opportunities in modern technologies in which there is significant Canadian technological strength;
- reduce efforts in technologies that are now better served by the private sector; and reorient the present effort toward major high priority programs;
- encourage cooperation with universities by strengthening and extending the range of contacts;
- endeavor to be better known in Alberta;
- strive for a higher profile and more recognition on the national and international scene.

ACTION PLAN

PLACE MAJOR EMPHASIS ON ENERGY RESOURCES — MAJOR EMPHASIS ON OIL SANDS RESEARCH NOW, WITH INCREASING RESEARCH ON COAL TECHNOLOGY.

At the present time oil sands and heavy oil research comprises about one quarter of the Alberta Research Council's budget and effort. Most of this work is funded by contracts, the Alberta Oil Sands Technology and Research Authority being the largest single client. Although this effort appears to be substantial, the opportunities and responsibilities in this field suggest that it should be expanded to at least double the present size. In this context, the Research Council will discuss needs and make proposals to the Alberta Oil Sands Technology and Research Authority, Alberta Energy and Natural Resources, Alberta Environment and to the industry.

Emphasis will be given to in situ work because most of the deposits are inaccessible by conventional mining. Nevertheless, good ideas applicable to surface mining will be considered, including materials and mechanical aspects. The principal programs on recovery and upgrading of bitumen will be supplemented with programs concerning protection of the environment, notably in groundwater and waste materials processing. As experience in oil sands builds up in the private sector, the Research Council could begin to decrease its efforts in about ten to fifteen years.

The Alberta Research Council's current coal research program is modest and almost entirely laboratory based, but provides a strong base for expansion. An underground gasification project was completed over a year ago with support from the public and private sectors. Coal is a potential source of premium liquid fuels, but, except for metallurgical and thermal power applications, it is not yet economic. This situation is expected to change in the next twenty-five years and the change could happen suddenly and unexpectedly. The Research Council has cooperated with Alberta Energy and Natural Resources in the development of a program of coal research in Alberta to be funded by the Alberta/Canada Energy Resources Research Fund. As a result, the Research Council is proposing major programs in coal conversion and underground gasification. This will form the base for a more diverse program such as that now in place in oil sands technology. The cooperation of the private engineering consulting industry and other firms with interests in coal will be actively sought in this field.

The area of conventional oil and natural gas is well served by the private sector, the Petroleum Recovery Institute and the Computer Modelling Group. At the present time the Research Council has no significant programs in it. Nevertheless, because the smaller exploration companies need general background information, regional geologic studies to develop information applicable to discovery of oil and natural gas in deep basins will be proposed. Other applications of the Research Council's membrane gas separation process will be terminated, except on contract request. The Research Council will be alert to other opportunities as they arise.

The use of alternative energies is relatively unimportant in Alberta. The Alberta Research Council runs a modest solar and wind energy research program and will continue to follow developments in solar, wind, biomass and geothermal energy technologies. Through its industrial assistance program, the Research Council will provide information and assistance to firms interested in these fields, but no major expansion of the program is planned. In the very long term nuclear fusion could provide abundant energy, but this enormous undertaking will have to be tackled on a national or international scale. If part of any future Canadian program can be brought to Alberta, the Research Council will be prepared to assign staff to it. At the present time the best opportunities lie in learning how to conserve energy, and the Research Council will work with government departments and with industry in developing and implementing energy conservation programs.

INCREASE ASSISTANCE TO SMALL, MEDIUM AND LARGE COMPANIES BY SEEKING NEW AND FLEXIBLE WORKING RELATIONSHIPS.

The transfer of technology, particularly to the private sector, is one of the Alberta Research Council's principal objectives. At the present time there are several ways in which the Research Council achieves this objective. These include:

- the technical assistance and information program, operated in conjunction with the Technical Information Service of the National Research Council;
- contract research, performed on a conventional consultant-client basis;
- technical assessment contracts, in which a contractor, such as an engineering firm, is employed to assess a new technology and to assist with marketing and developing;

- contracting out some Research Council support work;
- joint projects with firms, involving joint action, joint subscription or both;
- "do-it-yourself" research, in which an inventor or entrepreneur leases space and some assistance in order to carry out development of his invention;
- licensing of Research Council employees to develop their inventions;
- licensing of Research Council inventions to interested parties;
- technical assistance and services to government departments involved in developing industrial incentives programs.

These services, which are offered throughout the province, will be modified in any way which will make them more effective and practical. For example, installation of a wider range of testing services is being considered. The Research Council will discuss these services with the private sector and work with Alberta Economic Development and Alberta Tourism and Small Business to improve them. This is a high priority area in which the Alberta Research Council, though strong, wishes to be stronger. The Research Council recognizes the delicate relationship in terms of competition with the private sector, but the intention is to help, not to compete. New ways of assisting the private sector will be explored, particularly the exchange of personnel and increased assistance to inventors.

ESTABLISH AN ENLARGED EXPLORATORY EFFORT IN FRONTIER SCIENCES TO PROVIDE A FOUNDATION FOR FUTURE ECONOMIC DEVELOPMENT.

As a provincial research organization, the Alberta Research Council believes that it has a responsibility to be aware of frontier sciences, particularly those which could have an important impact on the economy. It is proposed to approach this subject in a more deliberate and conscious manner than heretofore. For example, the Research Council believes that biotechnology will become very important within the foreseeable future and that, as has happened with other technologies, the results cannot be predicted. This is the time to enter this area, in order to be able to take part in and understand the developments which will inevitably come. At the present time the Research Council has a small but high quality effort in microbiology, its orientation being toward agriculture. It is proposed to use this as a basis of a working group which will define and propose a significant program within one year. Initiation of such a program will facilitate the attraction of competent people and will lead eventually to a broader base.

The connections with agriculture have been mentioned already. It is expected that the work will lead quickly into high technology development associated with the medical field, which would support the declared commitment of Alberta to a strong medical research program. Biotechnology is a frontier science already identified as having a potentially important impact on Alberta. The Alberta Research Council will be looking for other such opportunities.

PROVIDE SCIENTIFIC AND TECHNICAL SERVICE AND ADVICE TO GOVERNMENT DEPARTMENTS AND AGENCIES.

The Alberta Research Council currently provides a wide range of interdisciplinary scientific services to government departments and agencies. The Research Council has strength in the earth sciences (geology, soils and groundwater), these activities essentially composing the geological survey of the province. The disciplines involved in this activity are used to provide information for Alberta Energy and

Natural Resources, Alberta Environment, Alberta Agriculture and Alberta Recreation and Parks. A combination of expertise in water resources and civil engineering is used also by Alberta Transportation and Alberta Environment for its work on developing and maintaining the provincial road system.

Experience in chemistry and chemical engineering allows the Research Council to perform work in energy research, and a small but important energy modelling project is assisting Alberta Energy and Natural Resources in the development of energy policy.

A substantial proportion of the Research Council's contract work is done for many government departments and agencies. The programs are conducted on a client-consultant basis. Many issues arise during these consultations, among them the nature and value of the work proposed, the capability of the Research Council to perform it, and the possibility of doing it elsewhere. The Alberta Research Council will continue to work actively with provincial government departments and agencies to provide services as they are needed.

LOOK FOR OPPORTUNITIES IN MODERN TECHNOLOGIES IN WHICH THERE IS SIGNIFICANT CANADIAN TECHNOLOGICAL STRENGTH.

Although much of Canada's technology is imported, there are some home-grown strengths. Examples include telecommunications, specialized aeronautical equipment, pipelines and equipment for use in northern terrain. The Alberta Research Council is looking for opportunities in areas such as these. One area to be discussed with the Alberta government and other interested parties is telecommunications. Another proposal is to work with the Electric Utilities Planning Council and with appropriate government departments to develop a plan for electrical research, and to look for opportunities to participate in the Canadian Electrical Association's research and development program.

REDUCE EFFORTS IN TECHNOLOGIES THAT ARE NOW BETTER SERVED BY THE PRIVATE SECTOR; AND REORIENT THE PRESENT EFFORT TOWARD MAJOR HIGH PRIORITY PROGRAMS.

Reorientation of some of the Alberta Research Council's work is needed in order to increase the chance of its having a real impact on the province. This applies particularly to some projects related to the chemical industry, none of which industry is Canadian-owned and very little of which operates in Alberta or in Canada. It will grow in Alberta, but decisions to locate here will not be based on research done here, so we have little or no role to play. The Alberta Research Council has substantial skills in chemistry, there being more chemists than any other single group of scientists on its staff. They will be reoriented to strengthen major programs in oil sands and coal, which are potential raw material sources for Canadian industry, and perhaps in agriculture and forestry. This staff will be available on request for consultation with local chemical industry.

Agriculture is cited as an exception to the plan to move out of mature areas. Agriculture is a nationally owned business which traditionally has looked to governments to provide research. The rationale for continuing research is to protect a vital current business which will be with us for a long time. The Alberta Research Council is providing support only on a very limited scale to the total area of agricultural research. It has a few current projects in agriculture which tend to be chemically oriented. These fill a gap left by Alberta Agriculture, Agriculture Canada and the universities, all of which tend to specialize in non-chemical programs. Although its effort in this field is small at the moment, the Research Council has a particular reason for proposing to stay in it. It can be a starting point for a much stronger effort in biotechnology — a promising new area for the future.

The forest products industry, like agriculture, is one of the mature foundations of the Canadian economy. The structure of the ownership is quite different, however, the forests being publicly owned and the industry being substantially in the hands of large corporations. This industry is widely supported by well-organized and competent research organizations, which relate to the economic activity. Governments have tended to confine their research to woodlands problems and the industry has been interested mainly in research on products. The principal feedstock of the industry is softwood, of which Alberta has a relatively small, but extensively used, supply. Alberta has about one quarter of the total Canadian supply of hardwood, but unfortunately it consists mainly of aspen poplar, a species which is not in high demand. Although methods for using aspen poplar have been developed, there are few large-scale economic applications in Canada. It is unlikely that the Alberta Research Council could alter this situation quickly in any important respects, but in the long term it is likely that aspen will be brought into widespread use as the demand for forest products increases. The Research Council therefore proposes to work closely with Alberta Energy and Natural Resources and Alberta Economic Development in developing programs to exploit this resource. There will be many opportunities to contract work to the private sector and the Research Council expects to play an advisory role.

ENCOURAGE COOPERATION WITH UNIVERSITIES BY STRENGTHENING AND EXTENDING THE RANGE OF CONTACTS.

The universities perform a vital role in teaching, generation of new ideas and supply of trained personnel for all sectors of the economy. The Alberta Research Council already has a number of contacts with Alberta universities and wishes to increase and strengthen them. Activities which will be expanded include exchange of staff, participation of graduate students in research programs, joint seminars, visiting professors, shared facilities and projects, university staff on Research Council advisory committees, employment of university staff as consultants and research contracts with universities.

ENDEAVOR TO BECOME BETTER KNOWN IN ALBERTA.

Although the Alberta Research Council has served the province for many years, it is not as well known as it could be. Deliberate efforts will be made to maintain and strengthen effective two-way communication between the Research Council and the groups with which it interacts — industry, government departments and agencies, the universities, other research organizations and the public. These efforts will be aimed at increasing awareness of both the Research Council's activities and its ability to give assistance with scientific and technical problems, and at making the Research Council more familiar with the needs of the groups it serves.

The Research Council believes it should move closer to industry and the private sector. Since much of the province's secondary industry is located around Edmonton and Calgary, the establishment of at least some of the Alberta Research Council's effort outside Edmonton will be considered.

STRIVE FOR A HIGHER PROFILE AND MORE RECOGNITION ON THE NATIONAL AND INTERNATIONAL SCENE.

An excellent reputation is something which all research organizations try to establish in order to attract high quality staff. A reputation for excellence has a more subtle effect, however, in bringing credibility and prestige to its base, which in the Research Council's case is Alberta. This beneficial side effect can be of immense value in bringing new economic opportunities to the province. It can serve to support the private sector (the consulting engineering industry, for example) to gain access to outside markets. Recognizing that a good reputation is based on achievement, the staff are encouraged to participate in national and international science, mainly through publications and conferences at the present time, but also by winning contracts for research from outside the province. Examples are the cooperative work being done in oil sands with Venezuela and the contract for oil sands work with the Democratic Republic of Malagasay. Further encouragement will be given to the staff to develop more such contacts.

CONCLUSION

With this plan, the Alberta Research Council believes that it will be able to fulfil its responsibility to assist in the development of the province.

Alberta Research Council Long Range Plan
Research Staff Projections by Program
(Scientists and Engineers)

Research Program	1979 Man-years	1984 Man-years	Long Range Technological Outlook
ENERGY RESOURCES			
Oil Sands and Heavy Oils	49	80	Growth area for next 10-15 years
Coal	13	35	Growth area for next 20-25 years
Natural Gas and Conventional Crude Oil	6	5	Mature technology
Electricity	0	10	Growth based on opportunity
Alternative Energies	1	5	Growth based on opportunity
INDUSTRIAL DEVELOPMENT			
Assistance to Industry	22	40	Steady growth for next 20 years
Agriculture*	5	5	Mature technology
Forestry and Forest Products	0	5	Growth based on opportunity
Transportation	4	5	Mature technology
Minerals	10	13	Mature technology
Information Systems	5	7	Growth will depend on need
FRONTIER SCIENCES	2	10	Exploratory — high growth area
LAND, WATER, AIR SYSTEMS			
Land	12	20	Reduced growth after 10 years
Water	10	20	Reduced growth after 15 years
Atmosphere	21	25	Growth will depend on need
TOTAL	160	285	

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* For new activities see Frontier Sciences

Part II: Programs and Research Strategies

ENERGY RESOURCES

OIL SANDS AND HEAVY OILS

REVIEW

The oil sands and heavy oils will provide Alberta with a valuable advantage in development of its broad long range industrial strategy. The availability of assured, comparatively low cost energy is of major importance to Alberta industry. Furthermore, the major portion of the sales dollar from synthetic crude remains in Alberta or in Canada as payment for goods and services required for its recovery and upgrading, to the benefit of Alberta's secondary industry. This is in contrast to conventional oil and gas where a relatively low portion of the product value goes to goods and services purchased locally, and to imported crude oil which offers very little return on investment.

The present world crude oil crisis underlies the pressing need for alternative sources of liquid fuels to supplement the dwindling supply of conventional oil. At present, conventional Canadian oil supplies 65 percent of Canada's liquid fuel needs. Synthetic crude from the Alberta oil sands accounts for 5 percent. After exports to the United States of about 300,000 barrels per day, made up of both conventional and heavy oil, Canada's needs are satisfied with gross imports of about 700,000 barrels per day. Even under the most optimistic projection, the percentage of Canada's liquid fuel requirements which can be obtained from conventional Canadian oil will rapidly decrease, leaving an ever widening gap to be filled by alternative sources or by imported conventional oil.

The amount of energy available from the Alberta reserves of oil sands and heavy oils is massive by any standard. The known reserves are equivalent to four times the recoverable reserves of conventional crude oil in the entire world. Excluding the possibly large Carbonate Trend resource, the Cretaceous oil sands resource is over 1000 billion barrels. Although the size of the reserve is impressive, existing, proven technology can tap only a small portion of this potential.

Synthetic oil, produced by upgrading heavy oils and bitumen from the oil sands, is the cheapest alternative to conventional oil and it has an assured and expanding market. The production of synthetic oil will receive ever increasing national and international interest, which in turn will bring capital for development, recovery technology and, of course, a demand for a share of the resulting energy product.

In considering the value of this resource and its subsequent development, its geographic location has benefits that will become increasingly important. Compared to other Alberta and North American energy resources, northern Alberta oil sand developments will encounter relatively fewer alternative land-use conflicts. Water resources appear to be adequate, yet because the product can be transported by pipeline it suffers negligible disadvantage by its distance from population centres. However, the northerly location, with its cold climate, and remote, muskeg-dotted terrain, does impose harsh and costly demands on the recovery technology.

The technology associated with the surface mining and extraction is considered well advanced, and when the second commercial facility overcomes its initial start-up problems, the combined experience of two operating plants will provide a solid technological base for additional surface ventures. However, there are still major problems to be overcome before surface extraction processes can attain their full potential. Even then, the fraction of the resource which can be recovered by surface exploitation will be small. The major portion of the resource must be recovered by using in situ techniques. In contrast to surface mining, in situ technology is presently in an early stage of development.

The research commitment to oil sands and heavy oils, despite their economic and reserve pre-eminence, has been small compared to other North American energy sources. For example, the American effort in coal conversion technology has been an order of magnitude higher. The increase in funding by both government and industry in oil sands research and development in Alberta during the past few years is an important step in correcting this situation.

The recovery and upgrading of oil sands bitumen and heavy oils is an extremely costly enterprise, so much so that these undertakings require consortia of multinational energy companies with government support at both the provincial and national level. This involvement of multinational organizations tends to favor carrying out the basic research and development of the technology in central research centres normally located outside of Alberta or Canada. Over the past ten years the Alberta Research Council, with substantial assistance from Alberta Oil Sands Technology and Research Authority, has built up a considerable research capability in oil sands technology. At present, 25 percent of the Research Council's effort is directed to this area with major emphasis on in situ recovery and development of a knowledge of the geology, geochemistry and hydrology of the resource.

It is important to explain the relationship between the Alberta Research Council and the Alberta Oil Sands Technology and Research Authority. The Research Authority is a crown corporation of the Alberta Government charged with the development of new technology for the recovery and processing of oil from the Alberta oil sands. Thus, although the Research Authority and the Research Council have quite different functions, they share similar objectives in the oil sands area. The forging of a partnership by these agencies represents a unique technological thrust that is leading to both domestic and international opportunities.

The governing Board of the Alberta Oil Sands Technology and Research Authority, as a policy, has chosen not to create research facilities of its own, but is using facilities of the Research Council to support and complement extensive programs being carried out by the Research Authority jointly with the private sector. Exciting opportunities exist for the Research Council, the Research Authority, and Alberta's private companies to cooperate in extending technical and engineering services to the many countries who have largely unexplored oil sand and heavy oil resources.

NEEDS AND OPPORTUNITIES

The major need is to develop processes for in situ recovery that provide for recovery of a high proportion of the resource at an economic cost and with minimum environmental side effects. There is also a continuing need to improve the economics of existing surface processes. Alberta has the opportunity to build a new energy manufacturing industry of world scale, and through this to develop experience in handling large projects and provide a base for assorted derivative industries.

Responsible development of the oil sands will require an in-depth and comprehensive understanding of the recovery technologies, economics, and the Canadian, North American and world energy-planning alternatives. An indigenous capability in these areas will also provide an evaluation and advisory function needed for support of governmental policy development.

An understanding of both the short- and long-term impact of the various oil sands recovery processes on the environment will be required. As the development pace increases, environmental impact will increase and technology will be required to minimize these impacts and to overcome environmental constraints.

STRATEGY

In recognition of the major needs required to support the development of an oil sand industry, the Alberta Research Council will expand its capabilities to develop suitable in situ mining technology. The Research Council's capabilities in selected areas of the technology of extraction from mined oil sands will also be expanded, with emphasis on those areas of the technology which are unique to the Alberta resource. These programs will be multidisciplinary in nature and will include significant support in the areas of geology, groundwater, energy planning, and technical evaluations.

RESEARCH PROGRAMS

In situ recovery technology.

The need for innovative development is pressing. To be significant, research must encompass a broad range of research skills integrated over several major areas.

The recovery process program will concentrate on the development of new recovery concepts. These concepts can be evaluated under reservoir conditions by using physical models in the laboratory. However, projection of these concepts to practical field situations will require development of an understanding of the basic reservoir properties controlling the process, the geochemical interactions, and sophisticated mathematical techniques.

The ability to recycle water from any thermal in situ recovery process will be essential. As the need for innovative technology in this area will become increasingly important, research into water treatment methods to recycle water will be undertaken. As well, evaluation is needed of boiler systems that can operate using less highly purified feed waters. The cost of drilling and maintaining wells will be the largest cost component of a commercial in situ operation. A program will be undertaken for the evaluation of drilling systems suited to the shallow, hot, high pressure environment that will exist in these oil sand recovery processes.

Extraction from mined oil sand.

Although the technology associated with surface facilities is considered to be well advanced, there is still need for innovations in many areas. Fundamental research is needed with a view to improving the present extraction processes to allow efficient handling of lower grade ore, improving both the extraction efficiency and the water reuse aspects of the process.

In the area of bitumen upgrading, programs aimed at improving the yield and quality of the various liquid fuels (gasoline, diesel), as well as petrochemical feedstocks, are important. There may be significant differences in processing the bitumen from an in situ process as compared with that from a mining operation. The program in catalysis will be strengthened to contribute to work on sulfur and nitrogen removal and on optimization of particular products.

Support areas.

Research into the fundamental sedimentology of the reservoir formations should be undertaken with emphasis on regional geological studies of bitumen-bearing formations to provide an interpretive framework for the evaluation of in situ processes, petrologic information in support of both mining and in situ development of oil sands, and obtaining a better understanding of the materials which overlie the oil sands areas.

In any major, large-scale development of oil sands, water availability and its reuse and disposal will be a constraining issue. A network of wells for monitoring groundwater has been set up in the Athabasca deposit. A continuation of these monitoring schemes, with expansion into new areas, particularly those suitable for surface mining, will be important to further development.

In support of the proposed Research Council technology development in oil sands, as well as in coal and other energy forms, programs will be undertaken to provide an in-depth understanding of general energy-planning alternatives and their economic significance. As well, technical evaluation of new oil sand processes or modifications to existing processes will be carried out.

FINANCIAL SUPPORT

At the present time, most of the Alberta Research Council's work on oil sands is supported through contracts with sponsors in both government and private sectors. The largest single contract is with the Alberta Oil Sands Technology and Research Authority and there are substantial contracts with industry. The Research Council will make proposals to these sponsors and will assist them to develop their programs in an effort to achieve the research programs proposed in this Plan.

COAL

REVIEW

The energy content of Alberta's coal resources is comparable to that of the oil sands and heavy oils. It is vast compared with any anticipated demand. Although the major reserves are of thermal coal, there is a sufficient supply of coking coal to satisfy an expanding demand within Canada and to allow further development of export markets. Coal deposits are widely distributed throughout the province but they are often located in areas which are environmentally sensitive or are set aside for recreation.

Worldwide research emphasizes improved methods of direct firing for power generation and of converting coal to liquids and gases. The United States has a massive research program involving both government and industry covering all aspects of coal. The multinational oil companies are becoming active in coal research and in coal exploitation. Processes for liquefying and gasifying coal have been known for many years, but modern research and development is aimed at improved processes. There is one commercial plant in South Africa making liquids from coal by an indirect route.

Most of the coal now used in Alberta is burned to generate electricity, while all metallurgical coal is exported. Coal gasification provides a backstop technology to expensive conventional and frontier gas. Current projection of international crude oil prices suggests that products of coal liquefaction may be competitive with conventional oil in the 1980's. Coal is widely distributed throughout the world and is likely to be used as a source of liquid fuels to supplement diminishing supplies of conventional crude oil. The need in Canada will be met initially by oil sands but coal liquefaction is the next alternative.

The Alberta Research Council has had a modest but internationally significant program of coal research throughout its history. It has concentrated on coal chemistry and laboratory aspects of coal conversion and carbonization and, in addition, has done major work on coal geology in Alberta. A field test of underground coal gasification, supported by eleven companies and four government departments, was recently completed.

The Federal Department of Energy, Mines and Resources has been the only other continuing performer of coal research in Canada. Within the last year or so the Coal Mining Research Centre, dedicated to research on coal mining and beneficiation, has been established in Edmonton. A number of other research centres for coal are either set up or proposed elsewhere in Canada.

The principal source of government funding for coal research in Alberta for the near future is expected to be the Alberta/Canada Energy Resources Research Fund. This fund has already committed money for a building at Devon, to house Alberta Research Council's coal research and the Coal Mining Research Centre.

NEEDS AND OPPORTUNITIES

The primary need is an understanding of existing and developing technologies, and of the coal resources of the province in relation to these technologies. With this understanding, the Research Council can provide informed advice to industry and government. Knowledge of coal resources should cover the location and the amount and quality of deposits, as well as aspects of the geological and groundwater environments and the properties of the coal itself — what trace elements it contains, for example — which could produce environmental problems. Coals show great variations in their properties and the behavior of different Alberta coals in various combustion and conversion processes needs study. This last aspect requires broad knowledge of existing technology, at least at a level which will allow Alberta to participate in technical exchanges on a worldwide basis.

Once a good understanding of coal conversion technology has been built up, there will be the need to work on process improvements, either on selected existing processes or on new processes or subprocesses. The economics of coal conversion still need to be improved. Here there is an opportunity for Canadian companies to develop marketable processes or subprocesses. In coal combustion, there is a need to keep abreast of the latest technologies for combustion and for stack gas cleanup. Further studies are necessary on the coking properties of Alberta's coking coals, alone and in blends, in order to ensure their most effective use. Work on the development of underground coal gasification is required to maintain Alberta's place in this technology, and to provide for the efficient recovery of the energy from deeply buried or thin seams. In this area there is also an opportunity for Canadian companies and engineering firms to develop a significant position on the world scale.

STRATEGY

The recommended strategy for the Alberta Research Council is to develop, in conjunction with industry, major thrusts in coal liquefaction and underground coal gasification and to strengthen and build up technical competence over all areas of significance to Alberta.

Major emphasis will be on coal liquefaction and underground gasification. Coal liquefaction is important because liquid fuels are so essential to our whole economy and Alberta is firmly committed to supplying either natural petroleum or synthetic crude oil. Following a period of preliminary assessment, a major project on coal liquefaction will be proposed and initiated with active industry involvement. Underground coal gasification will be important to the utilization of much of Alberta's deep coal. The Research Council already has made a significant start in this field and has a chance of helping Alberta establish a leading role in the technology. The program will be continued with maximum participation by industry.

Research in coal mining is covered by the Coal Mining Research Centre. Research on combustion is carried out in Federal Energy, Mines and Resources laboratories and by industry. Alberta Research Council involvement in these fields will be to keep in touch without attempting distinct programs. In other areas of coal research — exploration, transportation, conversion, and carbonization — the Research Council will assume major responsibilities for providing the basis of the capability in the province.

RESEARCH PROGRAMS

Coal conversion.

Coal liquefaction will be the principal activity in the coal conversion program.

One or more continuous reactors will be constructed, at the smallest scale feasible, to test various liquefaction processes with Alberta coals. A survey will then be carried out, probably on a continuing basis as new processes are proposed, to obtain preliminary yet reasonably reliable indications of the behavior of, primarily, sub-bituminous coals in different liquefaction processes. This program should lead to the identification, in consultation with industry, of one or more preferred processes for use in Alberta and these should be expanded when appropriate, through the pilot plant and demonstration plant stages. Basic laboratory chemical studies related to liquefaction will need to be continued and new proposals for laboratory-level work on liquefaction will be considered as they come up. The present program on using bitumen or coker distillate as a coal-liquefying solvent will be followed up as long as it looks promising.

The present program on carbon monoxide-hydrogen and carbon monoxide-steam reactions as routes to liquid products will be reviewed critically and phased out unless new results justify continuation.

Work in gasification will give priority to production of hydrogen in support of the liquefaction program; that is, gasification of the residues from various liquefaction processes. Specific proposals for catalyzed gasification should be considered. Technical support will be offered as needed to any industrial initiatives to produce fuel-grade methanol or low- and medium-Btu gas for local use, but it is not expected that these areas will require major additional research.

Work on partial conversion of Alberta coals should be carried out to the extent of assessing the feasibility of economically recovering a liquid fraction from the coal prior to burning the residue in a power plant.

Underground Coal Gasification.

The work on underground coal gasification will be directed towards improving the reliability of techniques for linking between wells, and for achieving good efficiency of gasification of the coal section. Any promising ideas for improving the process for purification of hot product gases will be pursued. Environmental effects will be carefully studied and the economics will be assessed. Laboratory simulation and computer modelling will also be used when they can be helpful. Every effort will be made to secure active participation by industry.

Other Areas.

The Alberta Research Council has long been the major centre of coal geology in Alberta and there is much more work to do, particularly with respect to the geological environments of coal deposits. In carbonization, studies of blends and special pretreatment will be continued for Alberta's coking coals. The analytical survey of Alberta coals will be extended to cover trace constituents, and an adequate petrographic facility will be developed. The Coal Technology Information Centre will be continued.

Watching briefs will be maintained on developments in coal slurry pipelines and in combustion and related aspects of stack-gas clean up. Experiments with coal slurries can be arranged with the Saskatchewan Research Council and, in the area of direct firing, Alberta can rely on the Energy, Mines and Resources program of the Federal Government.

The Research Council's capability in catalysis and surface chemistry will be aimed at supporting the work on coal conversion. A high level of expertise in catalysis will also be of assistance to various phases of bitumen upgrading. Another area that is important to research on coal, oil sands, and other energy sources is that of technical evaluation and general studies of energy planning. This area, which is essential if the Alberta Research Council is to make sound recommendations concerning relative priorities for different fuels and different processes, will be strengthened.

NATURAL GAS AND CONVENTIONAL CRUDE OIL

REVIEW

Natural gas and conventional crude oil are dominant energy sources in Alberta. They have been the principal contributor to the government's income from royalties and leases. With increasing prices, there is renewed exploration activity and major additions are expected to known reserves. In the case of natural gas, discoveries are being made in unusual types of formations, such as the Deep Basin, where it is difficult to estimate how much gas may be recoverable. In addition, there are discoveries being made of more conventional, but usually smaller, deposits. Additions to reserves of conventional crude oil will come largely through improved recovery techniques and from new discoveries, although they will probably not be sufficient to satisfy Canada's needs.

The industry is mature and is characterized by a wide spectrum of company sizes, degree of vertical integration and foreign control. The major energy multinationals dominate the refining, processing and marketing phases of the industry and also look after their own research needs. Small- and intermediate-sized companies are significant in exploration and production; these companies are largely Canadian owned and have relatively little research capability.

Gas processing — that is, treating natural gas to remove acid gases like hydrogen sulfide and to recover useful higher hydrocarbons like propane — has become a significant aspect of the industry in Alberta. Alberta firms have developed a high level of technological capability in gas processing.

The Petroleum Recovery Institute in Calgary, which is supported by Government and industry, carries out research mainly on improved recovery methods for conventional crude oil.

The Alberta Research Council has in the past carried out regional geological studies related to natural gas and crude oil exploration. Work arising out of the research on groundwater flow patterns has led to a new theory for the formation of oil deposits and this could be useful in exploration. Work has been done in some aspects of natural gas processing, and the Research Council has taken a lead in developing membrane processes for separating gas mixtures.

NEEDS AND OPPORTUNITIES

There is a need for regional geological syntheses that will assist the smaller companies in their exploration programs. Such studies are too expensive for any single small company and extend beyond the area of immediate interest to the company. Regional geological studies may also be required in support of the production of natural gas from unconventional reservoirs.

A possible need exists for geological studies of the characteristics of unconventional gas reservoirs. This will be evaluated further in discussion with potential users.

There is an opportunity to make a significant contribution to exploration technology by following up on the work already done on the theory of oil deposits. In the area of gas processing, there is an opportunity to help Alberta develop a dominant position in membrane technology for gas separation.

STRATEGY

The Alberta Research Council will concentrate its research effort in two areas: the study of the geology of oil- and gas-bearing formations, and the separation of gaseous mixtures by improved membrane permeation technology. Research on petroleum reservoir engineering and production will be left to the Petroleum Recovery Institute and to the Computer Modelling Group in Calgary. The work on the accumulation of oil deposits will be continued (see page 54 in the section on Water).

RESEARCH PROGRAMS

Regional geological syntheses.

The Alberta Research Council will continue the program of regional geological studies of the principal oil- and gas-bearing formations. This program will be defined in consultation with industry and with Alberta Energy and Natural Resources.

Separation of gaseous mixtures.

The Research Council will continue to work with Alberta Helium Ltd., and possibly other companies, in developing the technology of membrane permeation for the separation of gaseous mixtures. Activity in other aspects of processing and refining will be limited to responding to requests from industry.

Gas processing.

It is anticipated that the Research Council's work on the Claus process will be phased out unless a specific request from industry warrants its continuation.

ELECTRICITY

REVIEW

The generation and transmission of electric power are technologies in which Canada has a strong position because of a substantial background of expertise. The Research Council is looking for opportunities to contribute to this knowledge — to help maintain and develop a strength in this field in Alberta. Although much of the existing electric power industry relies on an essentially well established technology, future developments are expected to be greatly influenced by new technologies.

In Alberta the electric utilities are privately or municipally owned, in contrast with most other electric power industries in Canada. They coordinate their planning through the Electric Utilities Planning Council, which has predicted that between 1976 and 2006 there will be a seven-fold increase in demand from 16,395 Gigawatt hours to 117,276 Gigawatt hours. The electrical industry is expected to play an increasingly important role in Alberta, with major expansion to a growing electric supply industry, one can envisage the establishment of an electric manufacturing industry.

At the present time, a large portion of the Alberta electric utilities research needs are carried out through their participation in the Research and Development Program of the Canadian Electrical Association. This program is jointly funded by the Canadian electric utilities and the federal government. The electrical utilities aslo participate in research through the work done by their various equipment suppliers. The Alberta utilities carry on specific research projects unique to their region, such as land reclamation.

NEEDS

In view of the forthcoming expansion of the electric industry in Alberta and of the increasing interest in electric energy exchange with neighboring provinces, there is a need to consider a research and development program that will:

- complement the research and development program of the Canadian Electrical Association, especially in areas that are of particular interest in Alberta;
- win greater participation for Alberta in the Canadian Electrical Association program;
- encourage and support manufacturing industry moving to Alberta;
- allow the Government of Alberta and the utilities to maintain their own expertise in dealing with such complex technical problems as interconnection with neighboring provinces, environmental impact of electrical installations, and the development of the electrical system for the entire province.

At the request of the Alberta Research Council, the Electric Utilities Planning Council has already identified a number of areas in which there may be a particular need to do research in Alberta. A few examples of the type of research areas identified follow.

- A continuing problem for the Alberta Interconnected System is the large variable loads such as steel mills and draglines. There are some significant control problems created on the system as a result of such loads impacting on a relatively small electrical system.
- Inductive coordination problems continue to be a source of concern between the electric utilities and the communications utilities. As the work proceeds in this area, there may be specific research areas which could be pursued.
- In Alberta there is a heavy concentration of pipelines and powerlines, and there is room for additional and more definitive research on the problems of the mutual coexistence of both systems.
- Much energy remains unused (wasted) as a by-product of electric power generation and of industrial processes. The Electric Utilities Planning Council has identified much of this unused energy, some of which cannot be recovered due to unavailable technology. Research into methods of recovering and using by-product energy would be useful.
- There is also a need to develop high voltage network analysis facilities.

RESEARCH PROGRAM

The Alberta Research Council will establish a small working group to develop and propose within one year a plan for electric research and development. This will be done in consultation with the electric utilities, Alberta Utilities and Telephones, Alberta Economic Development, the Energy Resources Conservation Board, and the universities, taking into account present and future needs and opportunities to participate in the Canadian Electrical Association's research and development program.

ALTERNATIVE ENERGIES

SOLAR ENERGY

Solar energy, because it is perceived as being clean and inexhaustible, evokes a great deal of enthusiasm in the public mind. This enthusiasm has unfortunately led to widespread misunderstanding about the availability and the effectiveness of solar power and has raised too many false hopes about it. Active solar energy systems are very attractive in many ways but they suffer from two main deficiencies. First, solar energy is intermittent and is required mostly when it is not available — during the night and during the winter. Second, it is too diffuse a form of energy. In the face of Alberta's northern latitude and abundant hydrocarbon resources, these fundamental problems make it unlikely that solar energy will play a very significant role in this province during the next twenty-five years. Solar energy technology is likely to be developed first in those areas where the needs are more pressing and climatic conditions more favorable.

Through its industrial assistance program, the Research Council will continue to provide technical support to companies trying to establish themselves in this field. It will continue to provide and develop its solar and wind energy technical information service under the Alberta/Canada Energy Resources Research Fund. While proposing no significant program in this field, the Research Council will continue to monitor the progress of this technology, particularly the program being carried out by the Canadian Government and the Department of Energy of the United States.

BIOMASS

One of the most important advantages of conventional fuels — oil, coal, and uranium — is that potential energy is concentrated in a relatively small volume and can be converted to a high grade energy, namely a high temperature. Biomass, especially in the form of trees, is a very effective means for capturing and concentrating solar energy into such a form. Some studies suggest that, if solar energy is to be collected and stored, this is the best way to do it. In fact, in a global context, firewood is still a major fuel. Nevertheless, in Alberta firewood is not likely to be important, because the cost of collection and the relatively low fuel quality, compared with oil and coal, will cause it to be uneconomic for many years yet.

The Research Council therefore proposes no program on fuel energy aspects of biomass, again with the qualification that good ideas will be considered and service will be provided on request.

WIND

Wind energy, like solar energy, is diffuse and unreliable and it is unlikely to be a significant source of power in Alberta. The Research Council does not propose to carry out any program in this area, but will monitor progress made by other agencies such as the National Research Council of Canada.

GEOTHERMAL ENERGY

Geothermal energy is important in some parts of the world where underground hot water sources are found near the earth's surface. Some sources are known in Alberta, but little is known about their extent or ability. While the Research Council does not propose to carry out any program in this area, it will monitor the research carried out under the Federal Government's energy research and development program and will make its scientific and technical expertise available on request.

NUCLEAR FISSION

Because of the large hydrocarbon resources of the province, electric energy from nuclear fission is not expected to be introduced in Alberta for several decades. Nuclear energy is sometimes suggested as a source of heat for recovering, and possibly also processing, bitumen from the oil sands. The prospects for this are not considered to be very high but the Alberta Research Council could usefully assist in research on some aspects of such an application. Otherwise the Research Council does not see any need or opportunity for it to do work on nuclear fission; the large effort carried out by Atomic Energy of Canada Ltd. does not need to be duplicated in Alberta.

NUCLEAR FUSION

Over the past five years Canada has considered, without yet making a firm commitment, embarking on a national program of fusion research. Over the past ten years, the University of Alberta has developed a strong group in the area of laser-fusion. Recently this group has proposed an expansion of its program as part of the Canadian fusion research program and has asked for Alberta Government support. If a part of the Canadian fusion program is to be moved to Alberta and is supported by the Alberta Government, the Alberta Research Council will commit initially the equivalent of one to two professional staff to participate in the Canadian program and to act as monitors for the Alberta Government.

ENERGY CONSERVATION

Underlying all the needs for new energy sources is the need to conserve what we have. Most people believe that a great deal can be achieved in this area, by changing lifestyles, building better houses, and designing more efficient plants. At the present time the Alberta Research Council is helping Alberta Energy and Natural Resources to develop ways to encourage the design and construction of energy-conserving buildings. This is an essential step to take before active solar energy technology can be used effectively but, of course, it will be applicable to all energy forms. It is believed that much can be done in this area by applying and adapting existing technologies.

The Research Council believes it can be most effective in this area by making its engineering and technical expertise available to industry and Alberta Government departments and agencies concerned with energy conservation. It will continue to keep informed of the progress of research programs in this area and will propose programs of its own if appropriate. For example, a research program on waste energy as a by-product of electrical power generation might be considered. In these programs the Research Council will involve the private sector to a large extent.

INDUSTRIAL DEVELOPMENT

ASSISTANCE TO INDUSTRY

REVIEW

Working with and helping industrial endeavors in Alberta is one of the Alberta Research Council's prime functions and highest priorities.

In Canada small- to medium-sized firms comprise about 95 percent of all manufacturing firms, accounting for 50 percent of the total manufacturing industry. Most of these companies are unable to maintain their own research and testing laboratories and often do not employ engineers or scientists. Because of this, they may be unable to define technical problems, and may have difficulty interpreting and using technical information. Medium- to large-size companies do not have these difficulties to the same extent, but occasionally need to call upon outside experts to help in areas where they do not have expertise. The situation in Alberta is much the same. In this province, about 97 percent of all firms fall into the small- to medium-size class, and many could benefit from access to external technical expertise.

Much of this assistance can be obtained from consulting firms in the private sector. The Alberta Research Council is sensitive to this desire of the private sector to provide services and does not wish to operate in areas best carried out by that sector. Research Council assistance to industry is concentrated on providing services not available elsewhere.

CURRENT ACTIVITIES

The Alberta Research Council has identified nine ways in which it works with and assists Alberta's business community.

- Under its *technical assistance and information program,* the Research Council provides free, short-term technical assistance and information, primarily for smaller firms.

  Providing access to technical information is a long-term, continuing effort which began shortly after the Second World War when the National Research Council set up the Technical Information Service to help disseminate much of the useful technical information accumulated during the war. The service is operated by the Alberta Research Council under contract from the National Research Council. The Alberta Research Council has supplemented the service with laboratory testing facilities operated by a qualified staff. Because the Research Council does not wish to come into competition with the private sector, the service is limited to short-term projects. Work is frequently referred to other laboratories and a Directory of Chemical and Physical Testing Facilities in Alberta is published by the Alberta Research Council.

- *Contract research* is performed on a conventional consultant-client basis for industries working in the fields of chemistry, chemical engineering and oil sands technology. This work is financed by the client.

- In *technical assessment contracts* a contractor, such as an engineering firm, is employed by the Research Council to assess a new technology and to assist with marketing and further development. This has several advantages. It gives the Research Council an honest and realistic appraisal of its work, and it introduces new technology to the private sector at an early stage. The direction of future research and development can then be planned more effectively and the private sector can begin to plan for implementation of new technology.

- *Contracting out of Research Council work,* for example, the assembly of experimental hardware, has recently led to opportunities for a private firm to develop a business which it would not otherwise have had.

- *Joint projects with private firms* can involve either joint action or joint subscription or both. The Alberta Research Council has successful experience with all three types.

- *"Do-it-yourself" research,* in which an inventor or entrepreneur leases space and some assistance in order to develop his invention, is a scheme being tried on an experimental basis. This is a new approach for the Research Council and it looks forward to successful experience with it.

- *Licensing of Alberta Research Council employees* to develop inventions made as a result of their employment is encouraged. It is by mechanisms such as this that high technology industries in the Boston and San Francisco Bay areas of the United States developed.

- *Licensing of Alberta Research Council inventions* to interested parties is a more conventional and well understood route. The Research Council looks for the recovery of its research and development costs, and then favors a flexible scale of royalty fees, including a zero rate in some circumstances, in order to encourage Alberta industry.

- *Technical assistance and services to government departments* involved in developing industrial incentives programs.

These several different ways of transferring technology to the private sector illustrate some arrangements which have operated in the past few years. The Research Council does not believe these are the only possible ways. It remains prepared to respond to demand and is willing to consider any reasonable proposals.

PROPOSALS

Testing facilities.

Testing facilities will be expanded to serve the anticipated growth of industry in Alberta during the next twenty-five years. These installations will be selected in consultation with interested parties and will be geared as far as is reasonably possible to those industries already in Alberta or which are likely to come. The Research Council will undertake work requiring expensive equipment not easily afforded by small firms and will try to fill specialized requirements not provided by the private sector. New testing facilities will be organized in a way that permits transfer to private ownership if this should be desirable in the future. Facilities for which there appears to be a demand include equipment for testing metals, plastics and construction materials. The Research Council will continue to operate its Oil and Gasoline testing laboratory, which performs analytical services for government and industry.

Exchange of personnel.

From time to time the Research Council exchanges personnel with universities, but very few, if any, exchanges appear to have taken place with the private sector. The Research Council believes that in order to make its work more effective, it must find ways of working more closely with the private sector. It suggests that one way to do this would be to arrange exchanges of personnel with the private sector and will therefore explore the idea with interested companies.

Assistance to inventors.

The Alberta Research Council will continue to provide its traditional service to inventors through its industrial and engineering services program. In addition it will look for opportunities to enhance this work by using its access to key government departments such as Alberta Economic Development and Alberta Tourism and Small Business.

Increased awareness of technical services.

Efforts will be made to increase Alberta industry's awareness of the Research Council's ability to give assistance with technical problems.

Improved service in southern part of province.

The Research Council is concerned about its responsibilities throughout the province and is particularly aware of a need to improve accessibility to it in the southern part. The Research Council will work with Alberta Economic Development and with Alberta Tourism and Small Business to be more effective there. Increased regional staff will be put in place, and ways will be sought to install facilities while minimizing the problems of fragmentaton which now trouble the Research Council.

AGRICULTURE

REVIEW

Agriculture, along with food processing, is the largest employer in Alberta. It is competitive on the international market, and it is likely to remain so for some time. There is potential not only for development of new land for agricultural purposes, but for intensification of production on presently occupied farm and ranch land through the application of technology.

Historically, agriculture in Alberta has benefited from scientific and technological progress over the last century. Canadian research has contributed very largely to this situation. The principal accomplishments have been the development of early maturing crops for the short frost-free season, and the development of agricultural practices to handle the fragile soils of the semiarid plains. Most of the research is done by Federal and Provincial Departments of Agriculture and the universities, although industry has made major research investments in fertilizers, agricultural chemicals and food processing.

Agricultural research at the Alberta Research Council is not extensive, but it includes soil and water surveys, research on hail suppression, and a number of chemically oriented projects mostly done in collaboration with the University of Alberta, including utilization of wood for feed, preservation of wet grain and silage, and important developments in ammonia synthesis and nitrogen balance in soils.

NEEDS AND OPPORTUNITIES

There is an opportunity for the Alberta Research Council to use its experience in microbiology related to agriculture to initiate a frontier program in biotechnology.

Although all areas of potential use for agriculture have been surveyed, Alberta's southern and central regions need to be resurveyed with emphasis on the suitability of lands for irrigation and the preferred uses of land. The question of preferred use is particularly important around metropolitan areas, and the mapping must be sufficiently detailed to cover various possibilities of conflicting land use.

There is a need for groundwater research related to the problems of soil salinity and alkaline soils.

There is a need to develop a practical way to estimate local variability in climate (microclimate) from such observable features as topography, soil type and water drainage patterns.

There are increasing opportunities for expansion of Alberta food processing businesses and there may be opportunities for the Alberta Research Council to provide scientific and technical support.

STRATEGY

The Alberta Research Council will explore applications of biotechnology related to agriculture as the first step in the biotechnology program described under Frontier Sciences. This program will grow out of the existing activities of the microbiology laboratory.

Chemically- and microbiologically-oriented research in selected areas, similar to that now being carried out, will be pursued on an opportunity basis.

The evaluation of soils and water through resource surveys and work in weather modification will be maintained and expanded.

The Research Council will not get involved in the usual activities in plant and animal breeding but will depend on interaction with other agencies.

Recognizing that it is not the prime instigator of research programs in agriculture, the Alberta Research Council will make special efforts to maintain good communication with other agricultural research organizations and Alberta Agriculture. A large multidisciplinary organization like the Alberta Research Council can contribute a great deal to the solution of important problems on an ad hoc basis as well as on a project basis if more problems come to its attention.

PROGRAMS

Biotechnology.

A major, long-term study of low temperature biology will be undertaken. Subject areas being considered include developing novel ways to breed crops with greater frost tolerance, the improvement of the natural nitrogen fixation mechanism, and speeding up the decomposition of crop residues in soils.

Other applications of a biotechnology program include the use of plant hormones to regulate growth and crop drying, and genetic modifications to common grain crops to eliminate photorespiration. Work will be continued on applications of plant hormones for new herbicidal applications such as abscission or dormancy control. Further discussion of the biotechnology program is given in the section on Frontier Sciences.

Microbiology.

The Research Council will strengthen the existing program devoted to study of the microbiology of the rumen of cattle and sheep. Two aspects of ruminant digestion appear to be amenable to research at present. One is the suppression of methane production and the other is improvement of the efficiency of fibre digestion in cattle.

Agricultural Chemistry.

Two current projects being supported by the Farming for the Future program should be continued. The treatment of silage with sulfur dioxide is being pursued in collaboration with the University of Alberta. Research into the nitrogen balance of soils is a joint project with the University of Alberta, Alberta Agriculture and Agriculture Canada.

Other Programs.

Weather modification and agrometeorology are discussed in the section on Atmosphere. Soil survey and land inventory are discussed in the section on Land.

In consultation with Alberta Agriculture, the Alberta Research Council will consider whether it can make any useful contribution to developing an agricultural economic model for the province. The Research Council's experience in developing an energy model for Alberta might prove helpful. The Research Council will also explore the possibility of specific projects in food processing that could complement the work of other groups and will remain receptive to suggestions from Alberta Agriculture and industry.

FORESTRY AND FOREST PRODUCTS

REVIEW

Sixty percent of Alberta is covered by forest, mainly in the west-central and northern regions. About two thirds of the total forest is accessible. The softwood supply is a small proportion of the Canadian total and is extensively used for pulp manufacture in two modern plants. The hardwood of Alberta, mainly aspen poplar, is about a quarter of the total Canadian supply, but Alberta's supply is used only to the extent of about 2 percent. The reason for this low usage is that other species which produce more satisfactory products at acceptable costs are still in adequate supply. Although techniques for pulping poplar have been established, the short fibre product is not in great demand. Lumber cut from poplar suffers from dimensional instability if improperly cured. The history of the forest products industry provides many examples, however, of "unsuitable" species being exploited as supplies of premium species were depleted or assigned to specialized uses. Although its time has not yet come, it is likely that the poplar will be brought into use as the demand for forest products increases. The extent of the resource, both in relation to Alberta forests and total Canadian hardwood, is such that it cannot be ignored. It remains a reasonable challenge to exploit this resource.

The forest products industry, along with agriculture, has long been a foundation of the Canadian economy. It is a mature industry in the hands of large corporations, with extensive private and public research support. Research in forest management has traditionally been done in the public sector because of public ownership of the forests. Research on tree usage — lumber products and pulping — has been handled in the private sector by corporate laboratories and by trade associations. Suppliers of goods and services, for example, the chemical industry, have also contributed to this work.

The Alberta Research Council has considerable experience in soils, groundwater, geology and atmospheric sciences, which it believes would be of value to the Alberta Forest Service in, for example, reforestation programs. On the other hand the Research Council has essentially no direct experience in forest products.

NEEDS

There are no outstanding needs to be satisfied with respect to the use of coniferous trees. If there is any need in this area, it appears to be to increase the supply. There is a need to gain more experience in product development with poplar.

STRATEGY AND PROGRAM

The Alberta Research Council will explore with the Alberta Forest Service the possibility of contributing to work, for example, in reforestation, through the considerable strengths of the Research Council's earth sciences programs. In the area of product development, the Research Council will set up a working group with Alberta Forest Service and Alberta Economic Development to define a program and to look actively for opportunities to work with this well established part of the private sector.

TRANSPORTATION

REVIEW

The province's primary transportation networks are mainly in place. Most people and general freight move by road — in Alberta there are more than ten registered motor vehicles per kilometre of roadway, paved or unpaved. Railways are used primarily for the movement of bulk freight over long distances. The road and rail systems are facing steadily increasing demands in terms of traffic volumes and heavier loadings.

The annual investment made to provide and maintain all types of transportation facilities in the province is in excess of $550 million. Transportation, primarily road, is a large consumer of petroleum-based fuels; in an era of energy constraint, emphasis must be placed on preserving existing systems and making operational improvements to enhance transport efficiency.

Major technological changes in transportation equipment (vehicles, engines) will result mainly from events occurring outside Alberta. There is, for example, a pronounced trend towards smaller, more energy-efficient automobiles as a result of worldwide energy constraints. Most such technological changes tend to be gradual. There is, however, an identifiable need for the provision of road freight vehicles specifically designed to meet our system condition and climatic environment, particularily as related to major industrial development involving the movement of very large loads to remote areas.

Urban transportation systems planning and development, in particular mass transit (bus and light rail), is an area of continued growth. Problems of vehicle noise and air pollution may increase but these cannot be solved in isolation from a rational approach to land use. Pricing policies and land use restrictions could encourage moderate shifts to mass transit in the major urban centres. Nevertheless, rural transportation and commodity distribution, plus recreation and tourism needs, will continue to depend largely on the private automobile and the freight truck. A future dominated by continuing energy constraints will militate against any early development of futuristic "people movers" such as highspeed trains or magnetically levitated vehicles for intercity travel.

Much of the research into rail and air transportation is conducted by the industry in establishments elsewhere. Transportation research in Alberta is dispersed among the Research Council, the universities, Alberta Transportation and private consultants. The Research Council's present work on transportation is mainly integrated with the needs of Alberta Transportation, its major client in this field. Most of this transportation research concentrates on physical problems resulting from unique aspects of Alberta's climate, soils, available construction materials, geography, population distribution and industrial development. The Research Council has demonstrated expertise in capsule pipelining. This technology is readily exportable.

NEEDS

A precise identification of strengths and weaknesses of the provincial transportation picture is difficult to make due to the several modes involved, directed and regulated through a variety of agencies both public and private. For the dominant surface mode, there is a definite need for maximization and optimization of the existing systems to conserve materials, to maintain levels of service, and to save energy by operational improvements. While the primary road system can be maintained by timely improvements, more exact design criteria need to be developed for the low-volume secondary road system being developed. Economical substitutes for conventional road making and structural materials, such as sulfur and flyash, require extensive evaluation, as does potential for recycling existing in-place materials. Traffic allocation and commodity flow forecasting methods require improvement in both data bases and predictive routines. Operational improvements required to maximize system capacity require further investigations of roadway geometries, signalization and markings, and guidance and communications systems.

Increasing traffic demand leads to a heightened concern for operational safety. This must deal not only with the condition of the physical plant but also with the human factor — driver attitude, behavior and perception. Extensive field and laboratory studies of driver psychology under actual or simulated operating conditions are required.

STRATEGY AND PROGRAMS

The Alberta Research Council will continue its cooperative research program in support of Alberta Transportation. The possibility of developing more research in support of cities, municipalities, and the private sector will be explored.

MINERALS

REVIEW

The minerals industry in Alberta is based primarily on commodities such as gravel, limestone and cement, and had a product value of approximately $477 million in 1978, including by-product sulfur from sour gas processing. This represents 6 percent of the manufacturing industry. Alberta industrial minerals are generally high-volume, low-value commodities for which transportation costs form a major component of the consumer price. A notable exception to this is sulfur, a major export product. There is almost no metallic mineral production in the province, but the potential exists for the discovery of uranium, lead and zinc deposits in northern Alberta, and the production of zirconium and titanium as a by-product of oil sands processing. A steel industry based on the Clear Hills sedimentary iron deposit is a possibility if processing difficulties can be overcome; the Alberta Research Council has invented a new process which is being evaluated economically.

Industrial minerals such as sand, gravel, limestone and clay are vital to maintain the continued economic growth of the province, with heavy use foreseen by the energy extraction and other petroleum-based industries such as petrochemicals. Government needs to know the distribution of minerals and their properties to ensure that development is rational, that land use planning is optimal, and that an adequate supply is available to maintain continued economic growth.

In general, the Alberta minerals industry is highly fragmented and characterized by numerous operators using relatively unsophisticated technology in mineral processing. Exceptions to this generalization exist, such as the presence of Sherritt Gordon Mines Ltd. at Fort Saskatchewan. Within the past few years mineral exploration in Alberta, and elsewhere in Canada, has been increasingly undertaken by oil companies based in Calgary.

At present Alberta's needs for the inventory and characterization of mineral deposits are handled by the Research Council, a considerable amount of this work being carried out on contract from Alberta Agriculture and Alberta Energy and Natural Resources. Expertise exists at the Research Council in the areas of recovery, beneficiation, transformation and utilization, but there is no coordination of minerals processing or utilization research, which is performed in response to external demands. No other government agencies carry out mineral inventories, but work on sulfur processing is handled by the Sulphur Development Institute of Canada, Alberta Sulphur Research Limited, and Unisul in Calgary.

NEEDS AND OPPORTUNITIES

There are two basic needs for minerals research in the province.

Firstly, it is necessary to maintain a thorough inventory and understanding of provincial mineral reserves as well as of minerals having resource potential if they are beneficiated. Information is required about the geologic and geographic distribution of minerals, their reserves, extractability, physical and chemical properties, utilization potential and amenability to beneficiation procedures. As a part of the inventory procedure a knowledge of minerals consumption will be maintained to note any changing trends, as well as awareness of supply and demand from domestic and foreign sources.

Secondly, technologies suitable for the beneficiation and processing of particular Alberta minerals will be developed and evaluated.

An opportunity exists in the province for the establishment of an iodine industry, using Alberta brines as a source.

STRATEGY

The general strategy will be to maintain up-to-date knowledge of provincial mineral resources and potential uses, so that current mineral information is readily available to government departments such as Energy and Natural Resources, Economic Development, and Tourism and Small Business.

Studies related to mineral beneficiation, processing and utilization will be done in response to external demand or as new opportunities are perceived by the Research Council. Work will begin on the Clear Hills iron deposit if results of the economic evaluation of the Research Council process are favorable. Also, upgrading low-quality Alberta minerals, such as industrial clays, and industrial wastes, such as gypsum tailings, will lessen provincial dependence on imports. As a need or opportunity is perceived, research will be undertaken to develop innovative uses for local minerals or to find ways of using Alberta minerals for novel applications developed elsewhere.

RESEARCH PROGRAMS

Mineral Commodities.

During the next five years, emphasis will be placed on completing commodity inventory studies including sand and gravel, limestone, phosphate rock, minerals from oil field reservoir brines, sedimentary uranium, salt in southeastern Alberta and the Fort McMurray area, and peat moss. The provincial sand and gravel inventory is currently underway and will take at least ten years to complete. User departments include Alberta Agriculture and Alberta Energy and Natural Resources.

Regional Inventories.

Compendiums of mineral resources and production and consumption trends on a regional basis will be done in response to requests from government departments such as Economic Development and Tourism and Small Business. Possible study areas include the East Slopes of the Rocky Mountains; the Cold Lake and Lloydminster heavy oils areas; and urban centres of Calgary and Edmonton, and possibly Red Deer and Lethbridge; the Grande Cache region (as a basis for diversifying the regional economy); and the Fort McMurray region to compile an inventory of the minerals used by an expanding industrial economy.

Minerals Processing.

Mineral processing research will continue on the Clear Hills iron deposit, providing that economic evaluation of this technology is favorable; otherwise research will be on an opportunity basis. Also, beneficiation research on Alberta ceramic clays and testing of clays and shales as possible sources of expanded lightweight aggregate will be undertaken in support of industry requirements.

Regional Studies.

Basic geological research related to minerals discovery and evaluation includes regional studies of surficial geology. Subsurface geological information presently being generated by mineral exploration provides the opportunity to study that portion of the Athabasca sandstone basin which occurs in Alberta. This basin is the site of the recent major uranium finds in Saskatchewan.

INFORMATION

The Alberta Research Council provides access to scientific and technical information in a number of different ways.

- The library provides conventional library services in the subject areas of interest to the staff and can obtain material from other libraries by inter-library loan.
- Specialized information centres contain computerized indexes and usually copies of the original literature on oil sands, coal, geology, groundwater, and solar and wind energy.
- Some 200 other commercial data bases covering a great variety of subjects consisting of bibliographic indexes and in some cases of abstracts can be searched on-line from a computer terminal through DATAPAC, an international switching system. This service is provided by the library and the information systems group.
- Information on particular subjects can be provided by individual staff members.

The library is primarily to serve the staff, but is available to the public as much as space and facilities permit. The other services are primarily to serve the public. The Research Council receives an estimated 25,000 technical enquiries annually; about 5,000 are handled by the five specialized information centres and most of the others by staff members.

The application of computer technology to dissemination of information is a rapidly expanding field, providing a significant supplement to traditional library services. The Alberta Research Council has played a significant part in organizing such services in Alberta and in contributing to the technology.

NEEDS AND OPPORTUNITIES

With the rapid growth of the province there is a need for ready access to scientific and technical information in those areas that are of particular importance to Alberta. In most cases the amount and complexity of the information means that some personal technical judgment is also required.

STRATEGY AND PROGRAM

The Alberta Research Council will continue to develop information systems at the divisional level. In general terms, the Research Council in the next five- to ten-year period will concentrate on developing information systems that are supported by ongoing research at the Research Council, and which will be available to the Alberta technical community.

FRONTIER SCIENCES

FRONTIER SCIENCES

The Alberta Research Council's mission calls for carrying out research work to meet needs expressed by Government departments and agencies as well as by industry. In most cases the research needs are of a short- to medium-term nature. The Research Council mission requires, however, that expertise be maintained and kept up to date. To do this the staff must keep itself at the frontiers of science. It is also through this type of research activity that the Research Council will be in the best position to assist Alberta to maintain in the long term its strong economic position. Current activities that might be considered at the frontiers of science include such things as studies of water-rock interaction, the development of theories of oil field formation based on groundwater flow patterns, some aspects of the work in homogeneous catalysis, and work in electro-organic chemistry.

In addition to activities at the frontiers of science such as the ones referred to above, which grow out of existing research projects, it is believed that the Research Council should give some emphasis to new areas which might be called frontier sciences. These will be new fields or subject areas that are considered to offer long-term opportunities for Alberta. In choosing these frontier sciences, it will be important to be optimistic as well as realistic for their possible ultimate benefits to Alberta, and to avoid fields which are largely pre-empted. The staff will be invited to make proposals for such activities, and proposals from outside the Research Council will also be welcomed and considered.

Perhaps the fastest growing field at the present time is that of the biological sciences. For a long time the science of living matter has been restricted by the inadequacy of our methods of studying it. Recent advances in physical analysis and chemical synthesis are beginning to overcome some of those obstacles, with the result that this field is now growing as chemistry and physics grew before it. It is very difficult to foresee what results will be obtained, but based on the experience with the earlier sciences, it is almost inevitable that new commercial opportunities will arise.

The Research Council already has a small microbiology group working in fields related to agriculture. This group will be asked to propose, with the help of recognized experts, a more substantial program than the one it is currently handling and to use such a program to attract competent staff. It is expected that building a program in this way will enable the Research Council to react quickly to opportunities in the medical area. Ultimately it will contribute to a provincial base for exploring commercial opportunities in biotechnology.

The broad field of computer technology and applications is an area of current rapid growth and great future potential. A number of Alberta companies are active in this field. The Research Council is involved in such aspects as information retrieval, data logging, and interactive graphics in support of its existing research programs. Possibilities for additional work will be considered.

LAND, WATER, AIR SYSTEMS

LAND

REVIEW

The greater part of Alberta is underlain by sedimentary rock. Glaciation of the area, which ended some 10,000 years ago, combined with post-glacial activity produced much of the materials from which the soils of the province have developed.

The soils are variable, ranging from the brown, dark brown and black soils of the grassland-parkland area to the thin gray and brown soils of the forested areas. The land generally consists of flat and rolling plains, topographically well suited to agriculture and to forestry operations.

Land has long contributed significantly to Alberta's economy. The total area of the province is about 66 million hectares. About 30 percent is developed for agriculture and the remainder is mostly covered by forest.

Alberta's agricultural industry has successfully competed on the world market for many years. Alberta has approximately 30 percent of the occupied agricultural land in Canada. The cultivated area is expanding, partly in new land and partly within settled areas where farmers are clearing, draining, and otherwise intensifying their use of the land. At present, some 20 million hectares are used in crop and livestock production.

Land supporting a forest cover amounts to about 46 million hectares in Alberta. The provincial forests contain in excess of 1.7 billion cubic metres of wood, thus ranking Alberta fourth among the Canadian provinces in terms of merchantable timber volume and productive forest area.

Alberta's population, energy and industrial development, and the need for land suitable for recreation, can be expected to increase significantly over the next twenty-five years. The competition for land, therefore, will assume even greater importance in the future.

Industrial development and the expansion of urban areas inevitably leads to some environmental degradation and land-use conflicts. Optimal planning will require decisions based on a thorough understanding of the total regional impact of various development projects.

The Alberta Research Council has over many years developed competence in the earth sciences — soils science, surficial geology, and hydrogeology. This combination puts it in a unique position. Such expertise will provide a base for multidisciplinary studies related to the interactions of land, water and air systems.

The Research Council has always worked closely with Agriculture Canada and with the University of Alberta in soils studies. It has also good working contact with Alberta Energy and Natural Resources, which has a small staff working on basic land inventories.

NEEDS

Responsible land-use decisions require a thorough and comprehensive understanding of land and its suitability or limitations for specific uses. To assist the planning process, a comprehensive inventory of land is required in order to achieve optimum use of this valuable resource.

New programs are required to provide the land-related information necessary for the wisest development of Alberta's energy, agricultural and forestry resources. As development increases, environmental impact will increase and technology will be required to minimize the degradation of land.

STRATEGY

The Alberta Research Council will expand the inventory program in soils and surficial geology in order to provide information upon which sound land-use decisions can be based. At the same time, studies will be undertaken to develop better methods of interpreting and using data gathered from these and other studies. Development of this program will be closely coordinated with user departments of the Alberta government.

The Alberta Research Council's present program in the reclamation of disturbed land is minor. Because of the projected expansion in energy development and urbanization, this activity will be expanded so that the total impact of such developments can be monitored and, where necessary, steps taken to carry out research related to the reclamation of disturbed land. Planning of expanded activities will be with the advice of the Land Conservation and Reclamation Council, Alberta Environment, Alberta Energy and Natural Resources, and Alberta Agriculture.

RESEARCH PROGRAMS

Soil inventory.

The soils inventory in the agriculturally important central and southern portion of this province is for the most part incomplete. Much of the information was gathered many years ago without the benefit of today's technology, and therefore it is generally inadequate and of minimal value for planning and development purposes. The Research Council will take action to complete the soils inventory in this area of the province, with priorities established in consultation with the client departments.

At the same time, the program of mapping the surficial geological deposits of the province will be expanded to complete coverage of the agricultural areas of southern Alberta, to map the areas to be affected by the development of oil sand and coal resources, and to survey certain portions of northern Alberta where existing surveys are inadequate.

Land use planning.

Research will be initiated into the interpretation of geological, geotechnical and soils data in order to quantify the suitability or limitations of the materials for specific uses.

Reclamation and erosion.

Industrial development may lead to the degradation of land at or near the developmental site. Research into the reclamation of natural resource extraction sites is intended to be a significant component of the program of the Alberta Research Council.

The continuous cropping of land may lead to soil degradation through erosion. A program to monitor the loss of soil from wind or water erosion will be considered with a view to improving management practices that will lead to maximum productivity but minimal soil loss through erosion.

WATER

REVIEW

Water is a key factor in the existence and evolution of society. It is indispensable for life and basic to any major industrial development. The anticipated industrial development in Alberta over the next twenty-five years will, therefore, be dependent to a large degree on an available supply of water. Oil sands, heavy oil and coal development, the petrochemical industry, agriculture and forestry, as well as urban and rural expansion and recreational developments will all require water. Water must be identified as possibly a seriously limiting factor to the continued development of Alberta.

Alberta's water resources are found both on and beneath the land surface. The distributions of surface waters and groundwaters are dissimilar. Surface waters are concentrated almost one-dimensionally, along thin linear bodies (rivers and streams); whereas groundwaters are widely distributed two-dimensionally, as a thin layer in the uppermost few hundred feet of the land surface almost everywhere in Alberta.

The average flow of Alberta rivers is 90 billion gallons of water per day; average groundwater discharge in the province is estimated at 6 billion gallons per day, a considerable part of which enters the rivers.

The quality of the water resources also differs: river waters have a few hundred parts per million of dissolved salts, whereas the groundwater resources may have up to 4,000 parts per million.

The natural occurrence of water resources in the province does not match well with the population distribution and industrial activity. Generally, there is abundant water in the north but lesser supplies in the south. However, with careful water management for a wide range of uses, Alberta should be able to meet requirements well into the future. Regional and seasonal deficiencies in the drier years, especially in southern Alberta, will require a wide range of management techniques oriented both to increasing supplies and using limited supplies more efficiently. The reuse of water at industrial locations is identified as an important water economy measure that requires investigation.

Water quality must be constantly monitored. Some industrial activities could lead to a deterioration in the quality of local surface and subsurface water supplies; these activities include mining for oil sands and coal, agricultural feed lots, chemical plants and even expanded urbanization.

In southern Alberta, the slow but steady spread of soil salinization is a concern that may well be affected or controlled to a large degree by groundwater flow systems.

In assessing the water availability and distribution in the province, it is important to remember that surface water resources straddle interprovincial and international boundaries thus coming under intergovernmental jurisdiction.

The Alberta Research Council has carried on programs in both surface water and groundwater research for some twenty years. It has been highly successful and has contributed significantly to the basic understanding of groundwater flow systems and of behaviour of streams and rivers in the province. Surface water activities are carried out as a joint program with Alberta Environment and Alberta Transportation.

Alberta Environment has extensive jurisdiction over water. It has responsibility for water management (including flood control and dam construction) water allocation and development, pollution control and waste disposal, and it also carries out groundwater investigations. Monitoring of stream flows is primarily the responsibility of Environment Canada, which also carries out water-quality monitoring. Alberta Transportation has responsibilities where roads cross rivers and streams, and when water, snow and ice cause damage to roads and bridges.

An active groundwater consulting industry operates in the province, and handles most individual water-development problems.

NEEDS

The orderly and efficient development of the province requires that a number of water-related needs be satisfied.

It must be recognized that water availability could be a constraint on future development. Consequently, evaluation of the quantity and quality of all water resources must be given important consideration, particularly in areas likely to be affected by developments related to energy. Resource assessments should be on a drainage basin basis as a support to management planning.

Where major water deficiencies are anticipated, inter-basin transfers are a potential solution. Evaluation of all potential impacts of such transfers is needed.

Fundamental to any such evaluation is knowledge of all aspects of the basic behavior of rivers, including those of river ice and floods, and of groundwater systems.

The expansion of recreational activities has resulted in the proliferation of country residences and increased use of water bodies. This greater use has increased the potential for pollution of both surface and groundwaters. Evaluation of the long-term effects of these changes is needed.

As forest management activities increase, the significance of groundwater as the source of moisture for trees is becoming more apparent. Studies are needed of the extent to which tree growth and tree distribution are controlled by groundwater, as well as investigation of the potential for manipulating groundwater systems to aid forest management.

As the water resources of the province are increasingly used, the need for information and advice on solving problems related to water increases. Both Government and the private sector play significant roles in answering these needs.

STRATEGY

In order to satisfy the needs in water research, the Alberta Research Council's water research program will be expanded, intensified and diversified. Close coordination with Alberta Environment will be necessary in planning and in operations with Alberta Transportation and with other clients.

Emphasis will be placed on areas affected by major energy developments in oil sands and coal, and where water is an important aspect or constraint in agriculture.

Studies will continue on the basic behavior of rivers in order to assess the effects of water management projects and other of man's activities on river systems.

Better prediction of floods is now possible as a result of the Research Council's technical developments in radar, and application of this technique will be promoted through Alberta Environment.

Water and ice problems relating to roads will be defined and studied according to the needs of Alberta Transportation.

A broad reconnaissance survey of groundwater resources has just been completed. More detailed resource evaluation work is now needed in areas of anticipated development and in areas where problems exist or are expected. Planning of this program and selection of areas for study will be made in conjunction with relevant Government departments and with planning agencies.

A better understanding of behavior of water under the ground will be sought as background to groundwater resources studies.

The Alberta Research Council will continue its hydrogeological research related to petroleum exploration, with the expectation of developing new methods of predicting the locations of oilfields.

RESEARCH PROGRAMS

River hydrology studies.

Examination of the basic behavior of Alberta rivers is fundamental to all management and development. This is considered to be a cornerstone to all other programs related to rivers.

Studies in developing regions of Alberta.

These programs will provide information needed for the orderly and efficient development of industrially active regions.

a) *Surface water.* Studies of river behavior and evaluation of the impacts of development on the river systems, including consumptive use of water, water diversion, and dispersion of pollutants.

b) *Groundwater.* Evaluation of groundwater resources, both quantity and quality. A program of a continuing nature with several two- to three-year projects. Problems such as those concerning slope stability and waste disposal are also envisaged.

Transportation-related activities.

The transportation-related water program covers several areas, such as hydraulics of bridges, ice impacts on bridges, and hydraulics of culverts. These studies will continue for the next several years in cooperation with Alberta Transportation.

Application of water studies for forestry, agriculture and recreation.

This area includes several subprograms, all to be implemented in close liaison with user departments and agencies, such as: amelioration of saline soils, with Alberta Agriculture; assessment of surface and groundwater supplies in recreational areas, and pollution hazards arising from development with Alberta Recreation and Parks; applications of groundwater studies to forest management, with Alberta Energy and Natural Resources.

Hydrogeological principles.

Evaluation of groundwater resources and development require a thorough understanding of water behavior underground. Work will continue on more basic studies including hydrogeological modelling, aquifer testing, and monitoring of groundwater behavior.

Information services related to groundwater.

There is a continuous demand in Alberta for highly specialized advice on a broad spectrum of water-related problems. The requests are far-ranging and originate with a number of agencies including Government departments, planning commissions, industry, consultants and private individuals.

The expertise developed by the Research Council in its other programs has direct application to solving many of these problems. However, Alberta Environment already provides a general information service on groundwater quality and potentials in Alberta, and therefore any Research Council activity in this area requires close liaison.

Hydrogeological applications to mineral exploration.

As conventional oil resources decline, exploration becomes more difficult and is less successful. New techniques of exploration will therefore be valuable. Consequently, the Research Council intends continuing its frontier-type research on the influence of deep groundwater flow systems on the location and distribution of oilfields. Other mineral exploration programs in the water sector will be initiated on an idea-opportunity basis.

ATMOSPHERE

REVIEW

The relatively low temperatures and the limited supply of atmospheric water in Alberta have an important impact on the future development of agriculture, forestry and industry in the province.

It may eventually be possible to modify weather effectively. At present knowledge in the field of weather modification is limited, but over the past decade activities in this type of research have increased significantly in the United States. Outside Canada, research on hail suppression continues, with more international cooperation, and efforts are also being placed on rain enhancement and snow augmentation. Snow augmentation experiments are now at the stage of practical application while hail suppression and rain enhancement research is still at the exploratory stage.

Climatological studies of rain, hail and convective storms have been underway in Alberta for many years. The climate and the weather are critical factors in agriculture, a major industry, as well as in urban and industrial development. Climatological studies have been initiated quite recently in the province to evaluate and possibly model climatic limitations to agriculture and forestry. Much of this work is being carried out in the northern portion of the province where the agriculture/forestry interface is of particular interest to land-use planners.

The Alberta Research Council has pursued basic research in severe storm and precipitation mechanisms for over twenty-five years and has oriented its effort towards atmospheric water management problems since 1973. Achievements include development of the technique of cloud-top seeding for hail suppression, carrying out the joint polarization radar measurements of precipitation, and developing a computer system for processing radar data. The only other Canadian program in this area has been a four-year research study of rain enhancement, at Inuvik and Ottawa, undertaken by Environment Canada. The Research Council is a recognized centre of excellence in this area, and has for the past five years worked closely with the Alberta Weather Modification Board.

Atmospheric chemistry research has generally been a minor activity at the Alberta Research Council. Much of the work in this area has been carried out by Alberta Environment.

NEEDS AND OPPORTUNITIES

Basic research is required to establish firmly the foundations of atmospheric water management (hail suppression, snow augmentation and rain enchancement) in order to evaluate climatic opportunities as they affect development alternatives in the province.

There is a need to determine climatic limitations to agriculture and potential crop production in the virgin lands of northern Alberta. Study is needed to determine whether this can be practicably achieved.

STRATEGY

The Alberta Research Council will increase its program in basic research related to atmospheric water management. In the long term, this research should lead to the development of a basis for better understanding of the mechanisms of precipitation formation.

In the field of agrometeorology the Research Council will, in cooperation with Government departments, evaluate the needs and potential modelling of climatic limitations to agriculture, and will assess its possible role in this area.

Any future effort in atmospheric chemistry should only be developed through consultation with, and in support of, Alberta Environment. In some instances the use of outside consultants to provide needed expertise will be considered.

RESEARCH PROGRAMS

Weather modification.

The knowledge and competence built up at the Alberta Research Council will be expanded to meet other needs related to weather modification management. The radar/computer technology will be applied to other fields such as flow forecasting, forest fire prevention, and hail and crop insurance programs. The technology will be developed to provide the tools necessary for the detection, identification, and measurement of precipitation types (rain, snow, hail) in and below storms.

Agrometeorology.

In coordination with Alberta Agriculture, Alberta Energy and Natural Resources and Agriculture Canada, the Alberta Research Council will attempt to develop a program to gather and interpret climatic data necessary for the development of agroclimatic maps of northern Alberta. At the same time, an effort will be made towards developing a numerical model to estimate climatic limitations for crop production as controlled by geographical location, elevations and the general characteristics of the landscape.

Alberta Research Council Long Range Plan
Research Staff Projections by Program
(Scientists and Engineers)

Research Program	1979 Man-years	1984 Man-years	Long Range Technological Outlook
ENERGY RESOURCES			
Oil Sands and Heavy Oils			
Bitumen Extraction	31	45	Growth areas for next 10-15 years
Bitumen Upgrading	4	10	
Support Areas	14	25	
	49	80	
Coal			
Coal Conversion	5	14	Growth area for next 20-25 years
Underground Coal Gasification	2	12	
Support Areas	6	9	
	13	35	
Natural Gas and Conventional Crude Oil			
Gas Membrane Permeation	2	3	Mature technology
Geology — Oil and Gas Recovery	0	2	
Gas Processing	4	0	
	6	5	
Electricity			
New Research Program	0	10	Growth based on opportunity
Alternative Energies			
Solar, Wind, Geothermal, Nuclear Fusion, Conservation	1	5	Growth based on opportunity
INDUSTRIAL DEVELOPMENT			
Assistance to Industry			
Technical Information Services	6	7	Steady growth area for next 20 years
Industrial Engineering, Oil and Gas Laboratory	16	33	
	22	40	
*Agriculture**	5	5	Mature technology
Forestry and Forest Products			
Forest Management	0	2	Growth based on opportunity
Aspen Utilization	0	3	
	0	5	
Transportation			
Highway Engineering	4	5	Mature technology
Minerals			
Minerals Inventory	8	10	Mature technology
Minerals Processing	2	3	
	10	13	
Information			
Information Systems	5	7	Growth will depend on need

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* For new activities see Frontier Sciences

Research Program	1979 Man-years	1984 Man-years	Long Range Technological Outlook
FRONTIER SCIENCES			
Biotechnology	2	10	Exploratory — high growth area
LAND, WATER, AIR SYSTEMS			
Land			
Land Inventory	8	12	Reduced growth after 10 years
Land Use Planning	1	2	
Reclamation and Erosion	3	6	
	12	20	
Water			
Basic Hydrology	2	4	Reduced growth after 15 years
Water Resource Evaluation	3	5	
Watershed Management	1	3	
Transportation Related Activities	2	3	
Advisory Services	1	3	
Minerals-Geochemistry	1	2	
	10	20	
Atmosphere			
Weather Modification	20	22	Growth will depend on need
Agrometeorology	0	3	
Atmospheric Chemistry	1	0	
	21	25	
TOTAL	160	285	

Alberta Research Council Long Range Plan
Research Staff Projections by Program
(Scientists and Engineers)

Discipline Activity	Chemistry	Physics	Biological Sciences	Engineering Chemical	Engineering Other	Geological Sciences	Soil Sciences	Hydrology and Hydrogeology	Atmospheric Sciences	Computer Sciences	TOTAL
Oil Sands and Heavy Oils	24 20			23 13	14 6	17 8				2 2	80 49
Coal	12 8			13 2	3 0	6 2				1 1	35 13
Natural Gas and Conventional Oil	0 2			3 3		2 0				0 1	5 6
Electricity		2 0			8 0						10 0
Alternative Energies		4 0		1 1							5 1
Assistance to Industry*	4 4	3 0	2 1	5 4	25 12	1 1					40 22
Agriculture	2 4		3 1								5 5
Forestry	2 0				1 0	1 0	1 0				5 0
Transportation					4 3					1 1	5 4
Minerals					1 0	11 10				1 0	13 10
Information	1 1		1 1							5 3	7 5
Frontier Sciences		1 0	8 1					1 1			10 2
Land			1 1			7 3	11 7	1 1			20 12
Water					3 2	5 0	3 0	8 7		1 1	20 10
Atmosphere	0 2				1 1				15 11	9 7	25 21
TOTAL	45 41	10 0	15 5	45 22	60 25	50 24	15 7	10 9	15 11	20 16	285 160

* The numbers refer mainly to the Industrial and Engineering Services program. About an equal number again are assisting industry directly in other programs.

1979 level of staffing —— 8
3 —— projected 1984 level of staffing

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